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Technology Demonstration Mission Program

The Bridge

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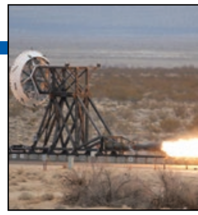

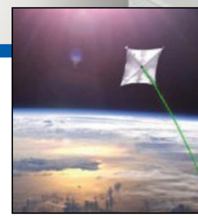
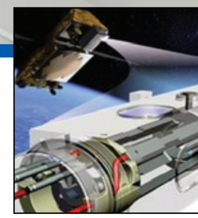


Green Propellant Project Team Propels Itself Through Key Reviews

The Green Propellant Infusion Mission, or GPIM, project team has propelled itself through successful subsystem and project Preliminary Design Reviews, or PDRs—critical NASA milestones in which the payload design, vehicle integration and associated ground support plans are deemed technically and programmatically achievable in order to fulfill the mission objectives.

The GPIM team is developing and will fly the green propellant demonstrator on a Ball BCP-100 spacecraft bus. The bus will be a secondary payload on the U.S. Air Force STP-2 mission set for late 2015. The GPIM team, led by Ball Aerospace & Technologies Corp. of Boulder, Colo., includes Aerojet Rocketdyne of Sacramento, Calif.; the U.S. Air Force Research Laboratory; the Air Force Space and Missile Systems Center at Kirkland Air Force Base, N.M.; and two NASA field Centers: NASA's Glenn Research Center in Cleveland, O.H. and NASA's Kennedy Space Center, Fla.

A Ball Aerospace researcher conducts laboratory tests on AF-M315E—the groundbreaking new propellant that will offer a high-performance, high-efficiency alternative to conventional chemical fuels. (Image: Aerojet Rocketdyne)

The subsystem PDR, held July 11 at Aerojet Rocketdyne, and the project PDR, held July 23–24 at Ball, demonstrated that the project met all requirements with acceptable risk and within cost and schedule constraints, and established the basis for proceeding with detailed design. The team received "a lot of positive feedback" during the reviews, said Chris McLean, principal investigator for the project at Ball Aerospace, and no critical issues were identified.

"We're excited by the GPIM team's successful completion of these milestone reviews," said John McDougal, manager of the Technology Demonstration Missions Program Office at NASA's Marshall Space Flight Center in Huntsville, Ala. "We're confident the project is on track to deliver a high-performance, high-efficiency alternative to conventional chemical

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'Sammy the Second' Highlights Impact of Deep Space Atomic Clock Project

An engaging animated character named "Sammy the Second" explores the value and potential impact of the revolutionary Deep Space Atomic Clock project—a NASA Technology Demonstration Mission—in a new video from NASA's Jet Propulsion Laboratory in Pasadena, Calif.

The 4-minute video illustrates the role of time in calculating explorers' positions—from early seafarers who circumnavigated the globe using clocks and the stars, to modern, satellite-based global positioning systems and deep-space radio navigation. It explains how the Deep Space Atomic Clock will demonstrate—in a space mission planned for 2015—the use of a small, mercury-ion atomic clock at least an order of magnitude more accurate than today's best navigation clocks.

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Green Propellant Project Team Propels Itself Through Key Reviews*... continued*

propulsion systems that will revolutionize how we safely and efficiently deliver new generations of exploration missions to space."

With the Preliminary Design Review behind them, the team continues work to complete the design, seeking to mature both 1 Newton and 22 Newton thruster technologies from the current laboratory models through flight-qualified designs. Most recently, Aerojet Rocketdyne achieved continuous operations of the 22N thruster and met its steady-state mission requirement goals.

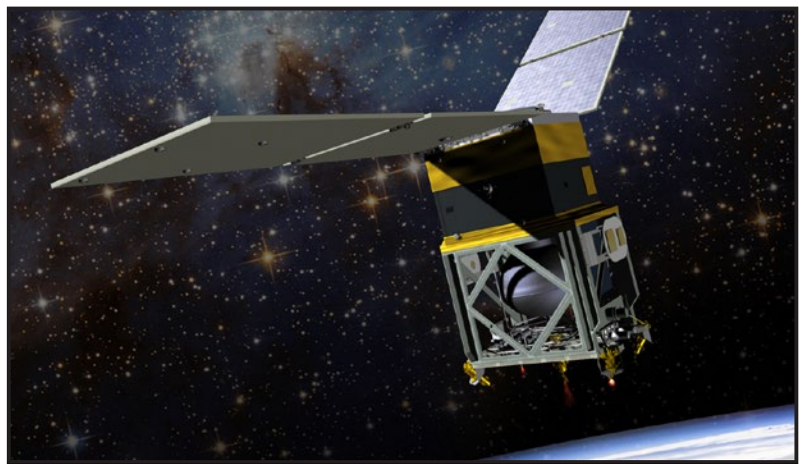
Thrusters are essential to the project, McLean said; they'll react the green propellant and initiate the spacecraft's orbit and altitude changes. The team selected the 1N and 22N classes of thrusters "because they represent the largest market share for this technology—and therefore the most direct path for infusion," he said.

NASA's newest Technology Demonstration Mission has received some high-profile media attention recently. Why? "The innovative propellant AF-M315E is relatively non-toxic and it has high performance," said McLean. "This mission also represents a rare opportunity to advance the state of the art in spacecraft propulsion technology."

And because of the new propellant's efficiency, ease of handling and loading, and other factors, McLean said AF-M315E presents the potential for significant cost savings per launch.

Read more about the project's latest milestone here.

Michael Gazarik, NASA associate administrator for space technology in Washington, shows off a scale model of a 22N thruster during a Green Propellant Infusion Mission press conference announcing the successful testing of the new thrusters by Aerojet Rocketdyne in partnership with Ball Aerospace, which is leading the green propellant project for NASA. (NASA/Keith Moon)



GPIM artist rendering.

Station Astronauts Remotely Control Planetary Rover From Space

By Rachel Hoover

Just as remotely operated vehicles help humans explore the depths of the ocean from above, NASA is studying how a similar approach may one day help astronauts explore other worlds. This summer, NASA tested the Surface Telerobotics exploration concept, in which an astronaut in an orbiting spacecraft remotely operates a robot on a planetary surface. In the future, astronauts orbiting Mars, asteroids, the Moon or other solar system bodies could use this approach to perform work on the surface using robotic avatars.

On June 17, NASA astronaut Chris Cassidy, an Expedition 36 flight engineer, remotely operated the K10 planetary rover in the "Roverscape," an outdoor robotic test area the size of two football fields at NASA's Ames Research Center in Moffett Field, Calif.

Cassidy wasn't at Ames, however; he conducted the test from his post aboard the International Space Station. For more than three hours, Cassidy used the four-wheel-drive, four-wheel-steer robot—which stands about 4.5 feet tall, weighs about 220 pounds and can travel about three feet per second—to perform a survey of the Roverscape's rocky, lunar-like terrain.

"The initial test was notable for achieving a number of firsts for NASA and the field of human-robotic exploration," said Terry Fong, Human Exploration Telerobotics project manager and director of the Intelligent Robotics Group at NASA's Ames Research Center in Moffett Field, Calif., which designed and manages the tests. "Specifically, this test was the first fully interactive, remote operation of a planetary rover by an astronaut in space."

On July 26, Cassidy's fellow Expedition 36 flight engineer, Luca Parmitano of the European Space Agency, continued the K10 remote tests. He used K10 to deploy several rolls of Kapton plastic film, which simulated a

Station Astronauts Remotely Control Planetary Rover From Space... *continued*

film-based radio telescope array—the kind that one day might be installed on the far side of the moon to make low-frequency measurements of the early solar system.

During the final test session on August 20, NASA astronaut Karen Nyberg remotely operated K10 to perform detailed visual inspection of the simulated telescope. The primary objective was to obtain high-resolution camera views to document the deployment. A secondary objective was to search for possible flaws, such as folds and tears, in the film.

These tests represent the first time NASA's open-source Robot Application Programming Interface Delegate, or RAPID, robot data messaging system was used to control a robot from space. RAPID, originally developed by NASA's Human-Robotic Systems project, is a set of software data structures and routines that simplify the process of communicating information between different robots and their command and control systems. RAPID has been used with a wide variety of systems including rovers, walking robots, free-flying robots, and robotic cranes.

These tests also marked the first use of NASA's Ensemble-based software—jointly developed at Ames and NASA's Jet Propulsion Laboratory in Pasadena, Calif.—in space for telerobotics. Ensemble is an open architecture for the development, integration and deployment of mission operations software. Fundamentally, it is an adaptation of the Eclipse Rich Client Platform, a widely used software framework for component-based applications. Since 2004, the Ensemble project has supported the development of mission operations software for NASA's Science and Human Exploration and Operations mission directorates.

The primary objective of the Surface Telerobotics tests was to collect engineering data from astronauts aboard the space station, the K10 robot and data communication links. This data will allow engineers to characterize the human-robot exploration concept and validate previous ground tests.

"During future missions beyond low-Earth orbit, some work will not be feasible for humans to do manually," said Fong. "Telerobots will complement human explorers, allowing astronauts to perform work via remote control from a space station, spacecraft, or other habitat."

Read the full story about the K10 tests here. To learn more about K10 telerobotics research, visit the Ames project page.

Hoover is a public affairs officer at NASA's Ames Research Center in Moffett Field, Calif.

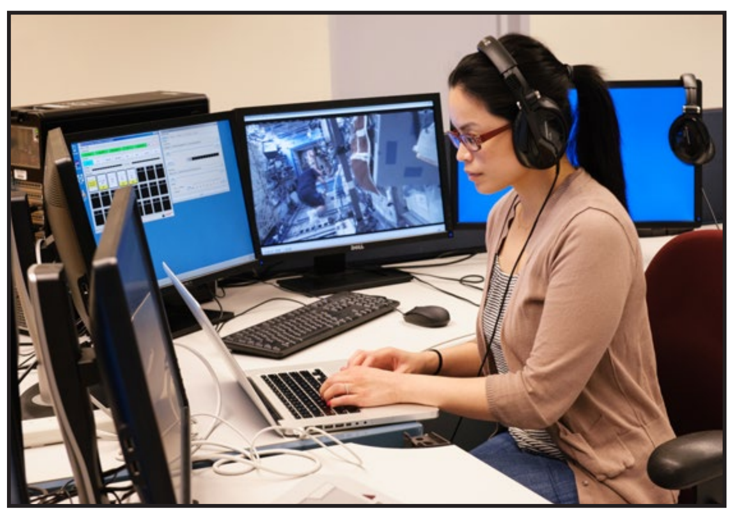
'Sammy the Second' Highlights Impact of Deep Space Atomic Clock Project... *continued*

Providing unprecedented timekeeping stability and calculating position in space down to the second, the new clock will improve the quality and flow of science and mission data back to Earth. It will enable precise, automated course corrections and could even aid spacecraft landing procedures at destinations across the solar system.

"Our little friend Sammy the Second is finally getting his due," the video narrator tells us, "paving the way for more precise, efficient space exploration one tick-tock-tick at a time."

The Jet Propulsion Laboratory manages the Deep Space Atomic Clock project for NASA.

The K10 planetary rover navigates the boulder field in the "Roverscape" during surface operations testing at NASA's Ames Research Center. (NASA/Dominic Hart)



Science lead Estrellina Pacis sits on console in the Multi-Mission Operations Center at NASA's Ames Research Center during a Surface Telerobotics Operational Readiness Test. (NASA/Dominic Hart)

Learning From LADEE:

The Benefits of the Hosted Payload Concept

From the TDM Program Manager

McDougal manages the TDM Program Office at the Marshall Center.

By John McDougal

On Sept. 6, I was on hand for the launch of NASA's Lunar Atmosphere and Dust Environment Explorer, or LADEE. It was amazing watching the U.S. Air Force Minotaur V launch vehicle send LADEE on its way to the Moon. It was a night launch, so it was quite a show. And it reminded me we're just over a year away from starting the launch process of one of our Technology Demonstration Missions—the "Sunjammer" Solar Sail Demonstrator—and just under two years away from launching two more—the Green Propellant Infusion Mission and the Deep Space Atomic Clock mission—both of which we're working on now.

LADEE, operated by NASA's Ames Research Center, has many similarities with our Technology Demonstration Missions, so there are some lessons we hope to learn. LADEE, a science mission, carried a hosted technology demonstration payload called the Lunar Laser Communications Demonstration, or LLCD (itself a precursor to the upcoming TDM mission Laser Communications Relay Demonstration, so we're watching the progress of LLCD closely as well).

Use of the hosted payload concept enables low-cost technology demonstrations by being able to piggyback not just on the launch vehicle but on the spacecraft bus as well. Like LADEE, many of our TDM projects need low-cost flight options and require the planned use of Air Force launch vehicles and processes. LADEE was a pathfinder through the NASA launch approval process—one from which we plan to benefit.

Working in the PowerPoint world of a program office, it's helpful to get out into the field, to be reminded that real hardware is being developed and flown. Watching a launch reminds me of what this is really about—putting hardware into space and conducting these Technology Demonstration Missions.

I look forward to watching our TDM projects' launch vehicles light up the sky.

McDougal manages the TDM Program Office at the Marshall Center.

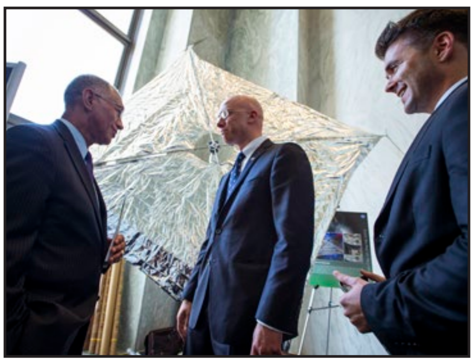
Technology (Demonstration Missions) Day on the Hill

NASA's Technology Demonstration Missions had the floor at the annual NASA Technology Day on the Hill exhibition, held July 23 at the Rayburn House Office Building in Washington. Sixteen members of Congress and approximately 500 staffers and guests mingled with NASA Administrator Charles Bolden, above left, and other agency team members, including representatives of five TDM projects: the Cryogenic Propellant Storage and Transfer, Deep Space Atomic Clock, Human Exploration Telerobotics, Laser Communications Relay Demonstration, and Solar Sail Demonstrator projects. The event was hosted by NASA's Space Technology Mission Directorate in Washington.
(Left image: NASA/Bill Ingalls; right image: NASA/Keith Moon)

Bridge Builder: Nathan Barnes

Nathan Barnes—president of L'Garde.

Editor's Note: TDM Bridge Builders are team members at various NASA centers and partner organizations who are helping bridge the gap, bringing one of our cutting-edge technologies to flight readiness. Got a suggestion for a team member worthy of a place in the limelight? Email richard.l.smith@nasa.gov.



NASA Administrator Charles Bolden, left, chats with Nathan Barnes, center, about the Solar Sail Demonstrator—one of the Technology Demonstrator Missions on display July 23 during NASA Technology Day on the Hill in Washington. (NASA/MSFC)

The "Sunjammer" project—NASA's Solar Sail Demonstrator—is being overseen by project manager and principal investigator Nathan Barnes, the president and chief operating officer of inflatable and deployable structures developer L'Garde of Tustin, Calif. The 13,000-square-foot solar sail, seven times larger than any solar sail tested in space to date, is set to launch to space in early 2015. In time, such sails could propel future NASA and NOAA station-keeping missions and other flight mission opportunities.

Barnes joined L'Garde in 2005, working as a project engineer on high-altitude airships. He has a long, practical history with technologies tied to flight—atmospheric or otherwise—having led and aided development of numerous deployable structures, lighter-than-air systems, unmanned aerial vehicles, and space-based deployable structures. It's also clear he's an avid space enthusiast of the old school; "Sunjammer" got its name from the title of a 1964 Arthur C. Clarke story written for "Boy's Life" magazine, in which the pioneering sci-fi visionary coined the term "solar sailing." "The Bridge" caught up with Nathan via email during a busy week in early September.

How do you hope your work will impact NASA's TDM goals?
"L'Garde is terribly excited to be involved in this twofold experiment. First, and most obviously, we are experimenting with and demonstrating solar sail technology—a truly propellantless propulsion that can offer significant benefits to future missions and, in fact, enabling some that could be achieved no other way. Second, we are experimenting with a new method of project management. As a small, commercial entity, we are bringing some different ideas to the table regarding the running of small space projects. Sunjammer is being run like a skunkworks program [nicknamed for the World War II-era Lockheed 'Skunk-Works' innovators who designed the P-80 Shooting Star] with a small, highly capable, very tightly coupled team. This approach leads to significant flexibility and maximizes resource efficiency."

What's the latest Sunjammer news?
"In two words: continued success. Our latest milestone is the successful deployment of a full quadrant of our 1,200-square-meter sail—one quarter of the total, flight-size sail. At 300 square meters, this quadrant already is the largest solar sail ever deployed! We are incrementally increasing the system complexity of our demonstrations, heading toward larger milestones in coming months."

What excites you most about the work you're doing?
"Long-term, the most exciting thing will be deploying the world's largest solar sail in space and navigating it through the heavens."

What's been your biggest challenge on this project? What has surprised you most?
"Time and money are not the only important resources for a project like this one. Guiding this project [has been] much more than just developing the best solution to the problem. It has been an exercise in balancing the desires and needs of a large contingent of stakeholders."

What's one thing most people would be surprised to learn about you?
"Most folks might be surprised to learn that my first paying job was as a bicycle mechanic." [The Wright Brothers ran a bicycle repair shop while conducting their early flight experiments—not bad historic company to be in, Nathan!]

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